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REVIEW: CONTRIBUTION OF BIOTIC AGENTS OF PAKISTAN IN WORLD AGRICULTURE

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ABSTRACT

Biological control has attained immense significance. Biological control is not unknown. It has a past history of successes. Natural control consists of two major components: environmental factors (abiotic) and natural enemies (biotic). Integrated Pest Management or Crop Management is considered a valuable tool in food security. It has not only been used in Pakistan but also Pakistani biotic agents have been used elsewhere in the world giving substantial economic control. These have been mainly used in the USA. With World Trade Organization protocols in operation, biological control will be of much significance. Import and export of natural enemies will be up scaling in recent times.

Keywords: Biological control, Natural enemies, World agriculture, Role, Importation.

INTRODUCTION

The need to minimize or avoid the depredations caused by crop pests has led to a diversity of management schemes, some of questionable value and others that stand today as testimonies to the skills of agricultural scientists. Natural control consists of two major components which are environmental factors (abiotic) and natural enemies (biotic). Integrated Pest Management or Crop Management is considered a valuable tool in food security. Biological control based IPM techniques have become quite popular. It is clear that biological control is attaining importance day by day. Biological control in an ecological sense can be defined as the regulation of natural enemies of another organism's population density at a lower level than would otherwise occur. Biological control is the use of parasitoids, predators, or pathogens to attack an insect and reduce

its number. It has the same fundamental objective as any other control measure, avoiding or minimizing economic loss. Attempts are made to place natural enemies in the environment and modify the environment to increase natural enemy numbers. Another method used to raise ratios is modifying established crop production practices so that natural enemies who are otherwise destroyed are conserved.

Biological control is not unknown. It has a past history of successes. There had been 214 cases of complete or partial biological control in the world. Of these, 116 had been in the Pacific region as follows: Australia, 10; Bali, 1; Bismarck Archipelago, 2; British Columbia, 9; Carolina island, 1; Celebes, 3; Chile, 5; Columbia, 1; Costa Rica, 2; Ecuador, 1; Fiji, 5; Guam, 4; Japan, 4; Marianas, 1; Mexico, 2; New Zealand, 10; Panama, 1; Peru, 5; Ponape, 1; Tasmania, 7; USA (California),

17; USA (Hawaii), 24 (DeBach, 1963). Complete control through natural enemies was achieved in 35 cases in the islands and 67 cases in the continent (total 102); for substantial control it was 58 and 86 (total 144) and for partial it is 36 and 45 (total 81). Thus, total for islands was 129 and continents 198 with a grand total of 327. There were following successes according to another compilation. Hawaii, 29; California, 23; rest of the USA, 29; Canada, 22; Australia, 14; New Zealand, 13; Fiji, 9; Chile, Tasmania, 8; Mauritius, Puerto Rico and Mexico, 7; Peru, USSR, Seychelles, Bermuda, 6; Israel, Greece, Kenya, Cyprus, 5 and 60 other countries or areas with 111 successes (Laing and Hamai, 1976). It indicates that successes were comparatively more on islands or isolated areas. In the continent, the successes were mostly in Europe. In the present scenario of world in relation to trade, environment, biodiversity and world treaties biological control is of much significance.

BIOLOGICAL CONTROL IN PAKISTAN

In Pakistan, work on biological control started in 1956 when the Commonwealth Institute of Biological Control (CIBC) was established. The work started on various projects of special interest. Investigations mostly centered on occurrence, incidence, distribution, and population fluctuations of different natural enemies.

The first basic fundamental input on biological control of Pakistan was put forward by Irshad (1968). Later on, Moyhyuddin (1981) compiled the research conducted on biological control in Pakistan. This was the basis the of start of applied biological control. The work was further

extended by Irshad (2003) who published the list of natural enemies of Pakistan. This includes 573 parasitoids, 152 predator, and 23 pathogens. To facilitate the research later on, Irshad and Khan (2005) published the pests and their natural enemies. This contains pests comprising of 38 Coleoptera, 23 Diptera, 232 Hemiptera, 21 Hymenoptera, 166 Lepidoptera, 22 Orthoptera, and 1 each of Neuroptera, and Thysanoptera. Jilani and Irshad (2008) compiled a list of natural enemies of food crops. Pollination has become an important component of the ecosystem in modern times (Irshad, 2014; Irshad and Stephen, 2014); and for the control of pests, pesticides are used and disrupt the population of pollinators; therefore a list of natural enemies was further strengthened for managing important insect pests (Irshad and Stephen, 2013). This data base has been used in applied biological control both nationally and internationally. The experiences of biological control have been documented in Pakistan (Haq and Irshad, 2011). The first striking biological control was of sugarcane pests in Pakistan (Irshad, 2008).

EXPORT OF NATURAL ENEMIES

Biological control consists of augmentation, importation, and conservation. In this paper, I will be dealing with importation or export of natural enemies to the countries of the world. A considerable number of natural enemies has been sent outside Pakistan. This list has been compiled by Irshad (2008). The list has been now modified and given in Table 1. These natural enemies have been utilized in the countries which have received these shipments. Some of these natural enemies have provided outstanding successes. Foreign exploration of biotic agents to

combat the menace of pests is very old. However, it became

Table 1: Natural Enemies Exported From Pakistan.

Country	Natural Enemy	Pest	Year	Reference
Bermuda	<i>Metaphycus lichtensiae</i> (How.)	Scale	1957-58	Clausen, 1978
Canada	<i>Tetrableps abdulgani</i> Ghauri	Wooly aphid	1962-1965	Kelleher and Hulme, 1984
France	<i>Aneristus ceroplastae</i> How.	Scale	1973	Muzaffar and Ahmad, 1977
Mexico	<i>Catana parcesetosa</i> (Sic.)	Citrus whitefly	1950	Clausen, 1978
	<i>Eretmocerus serius</i> Silv.	Citrus whitefly	1950	Clausen, 1978
	<i>Prospaltella clypealis</i> Silv.	Citrus whitefly	1950	Laing and Hamai, 1976
	<i>Prospaltella polenta</i> Silv.	Citrus whitefly	1950	Laing and Hamai, 1976
	<i>Prospaltella smithi</i> Silv.	Citrus whitefly	1950	Clausen, 1978
New Zealand	<i>Cotesia ruficrus</i> Haliday	Aphids	1969	Syed & Shah, 1969
USA	<i>Anysis saissetiae</i> (Ashm.)	Scales	1957	Clausen, 1978
	<i>Aphytis maculicornis</i> Masi	Citrus whitefly	1951	Clausen, 1978
	<i>Aphytis melinus</i> DeBach	Scales	1956	Clausen, 1978, DeBach, 1959, Laing & Hamai, 1976.
	<i>Coccophagoides utilis</i> Doult	Scales	1951, 1957	Clausen, 1978, Laing & Hamai, 1976
	<i>Prospaltella lahorensis</i> How.	Citrus whitefly	1910-11	Clausen, 1978
	<i>Tamarixia radiata</i> Waterson	<i>Diaphornia citri</i>	2013	Hodlde, 2012

popular with the introduction of *Rodolia cardinalis* (Muls.) coccinellid against cotton cushion scale in the USA. From here it has expanded day year by year. The leading countries are of the New World, especially the USA and its islands. It is due to the peculiar circumstances of the area as there pests emerged but biotic agents did not occur there. So exploration in the old world provided a lot of efficient biotic agents. Moreover, the USA put more funds and up scaled the human resource in biological control.

1. *Aphytis melinus* DeBach (Aphelinidae: Hymenoptera)

A. melinus, which was imported from Pakistan into the USA, is an outstanding success. About 2.5 million of *A. melinus* was released in 1957 and onward for several years to control scale, *Aonidiella aurantii*, in California. *A. melinus* has become the generally dominant parasitoid in California, especially in interior and intermediate areas where biological control was the poorest. By 1962, a general decline was evident and the pest reached to its

lowest level in many years, even though many insecticide treatments continued to be practiced. From California, it was redistributed to Cyprus, Greece and Israel and appears to be established there (DeBach, 1959; Clausen, 1978). The company Orcon Control Scale is selling 500 live adults @ \$58.87. Similarly Rincon Volta Insectaries' sells *A. melinus* \$ 5000/ cu @ \$18 and 1000 @ \$29.

Four species of parasitoids are responsible for the degree of biological control achieved in the USA. All were established between 1941 and 1957. Two species of *Aphytis* are, in general, the most effective of the natural enemies. Each of these alone can regulate California red scale populations at extremely low levels if habitat conditions are favorable to them. *Aphytis melinus* DeBach, imported from India and West Pakistan in 1956-57, must be rated number one. It is completely dominant in interior areas and generally in intermediate climatic areas, but is supplemented in its work by the red scale race of *Comperiella bifasciata* Howard, which was imported from south China in 1941 (DeBach, 1974).

Aphytis melinus spread rapidly following liberation in 1958, and soon displaced *A. lingnanensis* throughout the area. By 1964, *A. melinus* was the dominant parasitoid on *A. aurantii* in southern California, except along coastal areas, where *A. ingnanensis* remained common or dominant. There was a gradual decline in red scale abundance in southern California after 1962, which was attributed to these two parasitoids.

Its hosts are *Aonidiella aurantii* (Mask.), *A. citrina* (Coq.), *A. orientalis* (Newst.), *Aspidiotus destructor* Sign.,

Aulacaspis tubercularis (Newst), *Chrysomphalus ficus* (Ashm.), *Hemiberlesia lantaniae* (Sign), *Lindingaspis ferrisi* Mck., and *L. floridana* Ferris (Diaspididae: Homoptera) in Pakistan. It is distributed all over Pakistan. It has been reported in India and South Africa, also.

2. *Aneristus ceroplastae* How. (Aphelinidae: Hymenoptera)

Aneristus ceroplastae was introduced from Pakistan into France in 1973, where it is established (Muzaffar and Ahmad, 1977). It was introduced from India and Pakistan into Turkey, Italy, Greece, and the USA, giving substantial control of *Aonidiella aurantii* (Mask.). During the first year of release in 1958, the species was recovered from 31% of the released plots in the coastal area and 65% in other areas. Its effective rate of dispersal after colonization is far greater.

3. *Coccophagoides utilis* Doult (Aphelinidae: Hymenoptera)

Two species of parasitoids emerged from this single shipment and both were successfully cultured. Only one, however, *C. utilis* became established. By early 1961, it showed great promise of improving the degree of biological control of olive scale, *Parlatorai oleae* Colvee. This led to mass culture and colonization of over 4 million of the parasitoids during 1962-4 at over 170 sites in 25 counties. Widespread complete biological control resulted. Small releases of *Coccophagoides utilis* Doult totaling 14,500 individuals were made at 6 locations in 1957-58. About 2 million of *Anthemus inconspicuus* Doult were also released in 1958. *A. inconspicuus* seemed to have become established in 1958-59 and it had virtually disappeared by 1961 whereas *C.*

utilis had become well established. *C. utilis* was again released in 4 millions in 1962-63 in over 170 localities. The establishment of *C. utilis* has generally improved the biological control of *Paralatoria oleae* (Colv.) in California (Calusen, 1978).

4. *Coccophagoides* sp. (Aphelinidae: Hymenoptera)

Dr. Paul DeBach while searching for parasitoids of the California red scale in West Pakistan early in 1957 had gone to a remote village in the Tribal Territories where citrus had been reported (DeBach 1974). DeBach spent the day looking for other scale insect parasitoids on deciduous fruit trees and ornamentals. Olive scale was found and parasitoid activity was noticeable, especially emergence holes of internal parasitoids in dead scales. DeBach knew that no internal parasitoids were established in California, and therefore collected as much of this material as he could and then returned to Rawalpindi the next day, where he packaged it and sent it to the University of California at Berkeley by airmail.

5. *Prospaltella (Encarsia) smithi* Silv. (Aphelinidae:Hymenoptera)

In 1949-50, the collection of natural enemies was made from Pakistan and western India. Twenty-five shipments of field collected pupae of *Aleurocanthus woglumi* Ashby. were sent to Mexico in 1950. The receipt in Mexico of the series of effective parasitoid of citrus black fly and their early establishment stimulated the initiation of collection and distribution of a program unequalled in magnitude by any other biological control projects in the world. A gasoline tax was levied to defray the main costs and, at one time, about 1,600

men were engaged in various phases of the work (Clausen, 1978).

Its hosts are *A. citri*, *A. woglumi* (Aleyrodidae: Homoptera). It is distributed in Sialkot. It also occurs in China, the Far East, and Sri Lanka.

6. *Cotesia ruficrus* Haliday (Braconidae: Hymenoptera)

The Pakistani strain of *C. ruficrus* showed promise in New Zealand. Besides having savings of \$500,000 on insecticides, following their application in 1974-1975, New Zealand 80,00 tons of maize, instead of importing, and earned an additional several million dollars (Mohyuddin and Shah, 1977).

7. *Microterys flavus* (How.) (Encyrtidae:Hymenoptera)

Microterys flavus was probably an early accidental import from the Far East, where it effectively attacks *Coccus hesperidum* L. and some allied Lecaniine coccids. A race of *M. flavus* imported from West Pakistan was found in California to attack *Saissetia oleae* (Oliv.) but otherwise did not differ from the local race of the parasitoid. It was released against *S. oleae* on various plants in 1957-59. The distinctive host-preference pattern for *S. oleae* by the Pakistani race was examined in the laboratory when no other hosts were available. When alternate hosts were provided, the local race was preferred. Acceptance of *S. oleae* by the Pakistani race restrained when the more favored host, *C. hesperidum*, was present. Variations in host selection between the two races of *M. flavus* were both to different host recognition criteria and to variable responses to stimuli inducing oviposition.

Host recognition stimuli included the attractive odor of living scale insects. Tests suggested the presence of a substance in *S. oleae* that inhibited host acceptance by the local race. A responsive movement within the living body of the scale was one of the basic stimuli for oviposition. Reciprocal cross mating between the two races showed that the acceptance of *S. oleae* as a host was inherited by progeny of either cross (Bartlett and Lagace, 1961).

8. *Tamarixia radiata* Waterson (Eulophidae: Hymenoptera)

Asian citrus psyllid, *Diaphornia citri* Kuwayama, has established populations in southern California USA in 2008. Foreign exploration efforts were focused in the Punjab of Pakistan, part of the presumed natural range of this pest and also an area which has a strong climatic match to the major citrus production areas of Southern California. Almost 2,000 parasitoids of *D. citri* were collected and returned to Quarantine at the University of California Riverside (UCR). The parasitoid guild was dominated by two primary parasitoids, *Tamarixia radiata* and *Diaphorencyrtus aligarhensis*. By June 2012, almost 5,000 *T. radiata* had been released in Southern California and initial field surveys tentatively suggest establishment is likely at about 20% of release sites. The classical biological control program is now entering a more aggressive mass production phase for *T. radiata* (Hoddle, 2012).

CONCLUSION

With the introduction of WTO and other phytosanitary measures, pesticide use has to be minimized. Thus, biological control has attained much importance. Export or import of natural enemies is

continuously expanding. Pakistan has large complexes of natural enemies which has not been fully explored. More attempts are need. The countries imported natural enemies of insects have gained tremendous benefits. Searches should be made in areas where target species are native. The climate and other conditions should be reasonably similar. Areas should be diversified. A large complex of natural enemies of different pests has been sent to various countries of the world. In the USA, California is one of the major recipients. It received *Aneristis ceropastae* How, in 1968, *Apytis* sp, in 1968 and 1969, *Comperiella* sp. in 1968, *Encarsia lahorensis* Howard. in 1968, 1969 and 1970, *Encarsia* sp in 1970, and *Eretmocerus* sp in 1970. Use of exotic and native species has given tremendous success in the USA and other countries. The exotic species are dealing in billion of dollars trade. Pakistan needs to utilize native species as we are lying in the Old World.

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Irshad: Contribution Of Biotic Agents Of Pakistan

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